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If the appearance of the more general work is to be long delayed, which is probable, owing to the magnitude of the undertaking, it is to be hoped that Mr. Scudder will soon give us a catalogue of the known North American species of this order. Such a catalogue, even though it were merely provisional, would be of great use to those having collections to arrange, and would stimulate more careful collecting in regions which have not yet been thoroughly explored. In this way much would be done to hasten the day when a fairly complete general work could be published.

One has only to consider the great usefulness of our lists of Lepidoptera to appreciate the value of even an imperfect catalogue. And there is no one else so well qualified as is Mr. Scudder to prepare a catalogue of the Orthoptera.—J. H. C.

PSYCHOLOGY.¹

Notes on the Experimental Study of Memory.²—The experimental investigation of memory began only a few years ago. In the books on modern psychology which date ten years back, there was no mention of it whatever. Wundt's treatise on physiological psychology, which may rightly be considered a typical work, devotes but very few pages to memory and not a word to experiments upon this faculty; nevertheless, this is a work which has passed through several editions, in which the author has endeavored to keep abreast with the science. The first investigators who directed their attention to the subject were Galton, Jacobs and Ebbinghaus; their studies were confined to a few points, and there still remain to-day many unexplored regions in this domain. The memory of sensations is merely outlined, and the memory of ideas still remains to be covered, at least for the most part. However, within the last two years, attention has been turned in the direction of the memory. Münsterberg, Calkins, Bigham, Müller and Schumann and many others have already published results which are exceedingly interesting, although still fragmentary. As it is certain that these studies are more likely than some others to render great service to pedagogy, it is to be hoped that the movement already begun will not be arrested too soon.

¹ Edited by Howard C. Warren, Princeton University, Princeton, N. J.

² Translated and slightly abridged from the *Année Biologique*.—H. C. W.

The experiments on memory, whether made collectively on an assemblage of persons, as (*e. g.*), on an entire class of students, or individually upon single subjects, or again on the experimenter himself, who serves as his own subject—these experiments, I say, consist chiefly in giving the subject a certain impression, and then seeking to find out what becomes of this impression in his memory at the end of a certain time. The experimenter endeavors above all to take account of the greater or lesser transformation which the memory causes the impression to undergo. To discover this, three principal methods are employed.³

1. *Method of reproduction.*—This consists in making the subject *reproduce* his impression; if it is a story that he has listened to, he repeats or writes it; if it is a visible form, he sketches it; if it is a sound or an inflection, or some visible movement, he imitates it; if it is a color, he reproduces it by mixing the tints on a palette or varying the sectors of rotating discs. This is certainly the most natural method, in that it follows closely our ordinary procedure; but as a method of studying the memory it is somewhat indirect; it requires a translation or transposition of the impression, and a special aptitude, *e. g.*, in sketching or painting; it should, therefore, be expressly reserved for the verbal memory. 2. *Method of selection.*—This consists in the recognition of the impression when it is presented again in company with others; thus a tint is exhibited at first and the subject must remember it; at the end of a certain time he is shown a graded series of the same color, comprising fifteen different tints, and must recognize the one which was shown him before; the second presentation may give the whole series simultaneously or successively. This method is simpler than the preceding, since it bears more directly on the memory; there remains to consider the sources of error which it contains. One has already been noted. Whenever we have to make a choice from among a set of objects our attention is drawn towards the centre of the series; if the impression to be recognized is the sixth in a series of 15, the seventh impression is more apt to be indicated than the fifth, because the former is nearer the centre; consequently the arrangement of the series, that is, the application of the method, exerts some influence upon the character of the results. 3. *Method of comparison.*—The subject compares the remembered impression with another impression which is shown him, and answers that the latter is “equal, greater or smaller.”

³ This classification of the methods for the study of memory was first proposed by V. Henri and myself; Baldwin has arrived at analogous methods quite independently.

Thus if it is a line that he is to remember, he is shown another line and judges the relation of the two.

These two methods may be used with many variations of detail into which we need not enter; it is sufficient to have shown that it is possible to make an experimental study of memory. I shall proceed to indicate the principal results which have up to the present been reached by science. There is, perhaps, no question of more importance to pedagogy. As I can only give a bird's-eye view of the whole, I will not mention any name, nor will I enter into the details of any experiment; it is sufficient to sum up in a few bare statements the results that have been attained.

1. *Partial memories.*—We know to-day that the memory is not a unit, but that there exists for each individual a series of partial memories which are distinct and independent; that these memories are unequally developed, and that in a certain number of pathological cases one of the memories may disappear altogether, leaving the rest intact or nearly so. The most striking example of this that can be cited is aphasia, a disorder in which the memory and images of words are affected in a special manner; the patient usually retains the memory and images of objects, and remains in possession of his intellect. Examples of the partial development of memory are met with among some professional exhibitors, such as chess players and (more especially) lightning calculators.

2. *The measurement of memory.*—Although the methods used for measuring the memory may have been crude, as they still are, it is nevertheless a great advance to be able to introduce the concept of measurement into this problem at all. So far attempts have been made to measure but one kind of memory, the direct faculty of acquisition. The experiments deal with the number of memory-images that can be stored up at a single trial, without allowing the subject time to rest. This is called in English the "mental span" of the memory; I have proposed for it the term "*faculté de prehension*." Several successive investigations have already been made on the measurement of the memory for figures and syllables; these are localized memories, the development of which cannot be considered as a sign of the development of the other memories; we must, therefore, make many reservations in interpreting the conclusions to be drawn from these experiments. The experiment may be made as follows: a series of figures is read to the subject at a regular speed (the speed used is in general two figures per second) and without any special accentuation; as soon as he has heard the series, the subject, having been told beforehand of

the requirement, endeavors to repeat the figures without error and in the order in which he heard them. The experiment is repeated several times, beginning with a small number of figures, *e. g.*, four, which any adult can give correctly; it is then increased to five figures, then to six, and so on, until a number is reached which the subject can no longer repeat correctly; care is taken to repeat each trial, and to allow sufficient intervals of rest to avoid fatigue and the confusion of figures in the memory. This procedure, adopted by Jacobs, Galton and many others, has already borne fruit. It is not, properly speaking, a test of the memory alone; it is extremely difficult, be it said in passing, to experiment on any isolated psychological phenomenon; the experiments taken together show, on the contrary, that the subject employs not only his memory but also his powers of voluntary attention; this explains why children retain fewer figures by this method than adults; their inferiority is certainly due to the fact that they have less control over their attention. The average educated adult retains seven figures; a child from 6 to 8 retains five; a child of 10 retains six. A difference of one single figure is of considerable importance in the results, and it is one of the drawbacks of this method that we cannot operate with fractions of figures. I have had occasion to measure the retentive memory of Jacques Inaudi, the celebrated lightning calculator; he is able to commit more than 40 figures at one trial; it will be seen from this how far his memory is above the average.

Instead of finding out the number of figures, letters or words that can be retained by one person after a single hearing or reading, a different procedure may be adopted; we may endeavor to find the time required by different individuals to learn a given number of figures, say twelve; further, we may try to find the time necessary to learn again a series once learned and afterwards forgotten. For details in regard to these rather complex methods I refer the reader to the work of Ebbinghaus. (*Ueber das Gedächtniss*).

A rather curious question, which is closely related to that of the measurement of memory, is the *simulation* of the memory for figures. Memory can be simulated as well as other things. This is done by means of mnemonics, a process which consists in associating arbitrary ideas with figures; I have indicated, in a study undertaken with V. Henri, how real memory can be distinguished from simulated memory, by measuring the time required to learn and reproduce.

3. *Forgetfulness*.—We now reach a question that has an important pedagogical bearing: the problem of forgetfulness. In what does it consist? What is its course? What memories are attacked first?

What are the best means to adopt for preserving memory-images? What should be done in order to strengthen the memory, etc., etc.? On all these points there have accumulated within the last ten years a countless number of documents; no synthesis of these data has yet been made, and I know of no general work in which the author has attempted to compare the results of these special studies and to draw forth their underlying principles; I except, of course, works on the mental pathology of the memory (Ribot, Sollier, etc.), which we are not concerned with here; I am only speaking of normal memory, studied with exactness by means of laboratory experimentation.

The analysis of these experiments leads us to one conclusion regarding the nature of forgetfulness. It is of two kinds, and is due to two principal causes: (1) *Forgetfulness through lack of retention*; the impression is not stamped in and does not leave a trace, this is the first kind; (2) *Forgetfulness through lack of reproduction*; the impression has been stamped in, but cannot be brought out or reproduced at will. *e. g.*, 100 words being read to a person, how many does he forget? The answer varies according to the way in which the term forgetfulness is interpreted. If we ask the subject to repeat the words, he will perhaps not be able to give more than 20, hence he has forgotten 80—forgotten them, in the sense that he cannot repeat them. This number can, therefore, be placed to the credit of forgetfulness through lack of reproduction. Now if we take these 80 words which the subject cannot repeat and mixing them up with one or two hundred new words, ask him to distinguish the old from the new words, we will see that he makes a very small number of errors; I suppose that on the average 60 words will be recognized out of 80, so that in the end there are scarcely 20 words in 100 (and, perhaps, even fewer) that are completely forgotten; the others were retained, inasmuch as they were recognized. *The amount of forgetfulness through lack of retention is always small.*

The position of the forgotten elements in a series of memories appears to be quite regular; the first elements in the series are almost always better retained than the rest, no doubt because they strike the attention when it is fresh; the same is true of the last elements, no doubt because they are the ones acquired most recently; most of the forgotten elements, then, belong to the centre of the series. The influence of novelty, repetition and other factors on forgetfulness have been studied (Calkins), as well as the influence of the time elapsed (in numerous investigations), the organ stimulated, the attention, distraction, etc. These investigations, many of them minute, have furnished us with matters of detail, rather than general ideas.—ALFRED BINET.